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ONTARIO DEPARTMENT OF EDUCATION

CIRCULAR G-S.17C.

CURRICULUM STUDY GUIDE FOR GRADE 13 PHYSICS

1965

ISSUED BY AUTHORITY OF THE MINISTER OF EDUCATION

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NOTICE

The attention of teachers of Physics is directed to paragraph two of page one of Curriculum S.17C, which reads as follows:

> "All topics listed should be treated quantitatively and in considerable depth, taking account of the scientific knowledge gained in the earlier grades. Those sections involving review of previous work will be covered fairly rapidly making use of experiments and reading assignments, but it is expected that they will be extended to include a reinterpretation in the light of modern theories. Problems are to be considered an essential part of each section of the course."

This paragraph should not be interpreted to indicate that each topic is to be studied exhaustively, but rather that considerable emphasis is to be given to the major principles presented in each topic.

Problems are considered to offer a vital insight into the significance and implications of the principles under study. It is therefore expected that a limited selection of problems will be carefully chosen for their intrinsic value in clarifying these principles.

November 1, 1965

PART A/GENERAL OUTLINE

1. Introduction

The purpose of the *Curriculum Study Guide* is to assist teachers with their presentation of *Curriculum S.17C, Grade 13 Physics.* As this course is based upon the course in Physics developed by the Physical Science Study Committee, both the objectives of the P.S.S.C. Physics course and the teaching aids developed to assist the teacher in attaining these objectives are applicable to *Curriculum S.17C* to a large extent. The new curriculum retains the essential development of the P.S.S.C. Physics course even though several complete chapters and portions of other chapters of the textbook, *Physics,* prepared by the Physical Science Study Committee, have been omitted.

2. Objectives

The new curriculum is so constructed that throughout the year the knowledge necessary to present a description of atomic structure in terms of modern wave-mechanic theories of matter is acquired. A realization of the inter-relationship which exists between experimentation and theory is gained by the students of this course. Emphasis is constantly placed on a thorough understanding of the physical principles involved and the application of these principles to new situations.

The student will study some of the fundamental concepts of physics, he will learn how knowledge of these concepts is obtained and he will learn to evaluate experimental data critically.

The new curriculum places a premium on the ability to reason as opposed to the ability to memorize.

3. Teaching Aids and Their Use

(a) The Textbook and Its Use

The textbook is written in a style which probably differs considerably from science textbooks which the students have used before. The authors of the P.S.S.C. Physics textbook have attempted to present the background information and arguments upon which the scientific principles are based so that the student will gain an insight into the approach of the scientist and a more thorough understanding of the concepts involved. The numerous illustrations throughout the book perform a valuable function in the presentation of the subject and should be given appropriate attention.

It is suggested that the students be encouraged to read in advance the portion of the text to be studied in a given lesson, and to make brief point-form notes on what they consider to be significant points presented. This will not only prepare the students for the lesson so that a deeper, more significant discussion can be developed in the classroom, but it will also help them to develop the skill to abstract the key points from a full presentation.

Problem assignments from the textbook must be given with considerable forethought. Many teachers have found it advisable to supplement the textbook problems with additional single-concept problems of their own design. Further comment on this aspect of the course will be found under heading 3(f) *Teacher's Resource Book and Guide.*

(b) The Laboratory Guide and Experimentation

As with any science course, it is essential that the teacher should perform the experiments and complete the required calculations and graphical presentations of data before the class does the experiment. The yellow pages at the back of the Teacher's Resource Book give many valuable explanations and hints on laboratory techniques and the treatment of the data obtained.

It is suggested that students should be informed of the experiment to be studied at least one week before the day on which it is to be performed. The relevant portions of the textbook might be drawn to the students' attention so that they can prepare an outline of the procedure and suitable charts for recording measurements. A few minutes might be taken at the end of a lesson to introduce the students to the apparatus to be used. Where possible it would be helpful to allow the students to come into the laboratory either before or after school in order to familiarize themselves with the apparatus and the techniques of its use before the day

of the experiment arrives. Teachers are urged not to present their students with complete method outlines beforehand.

Students should be advised to make repeat measurements of each quantity and to take a number of measurements where a series of measurements is necessary. Where graphs are to be drawn it will be found helpful to provide the students with a celluloid holder for a sheet of squared paper, and a china-marking pencil. The students can then make rough graphs of their data as the experiment progresses. This will enable them to determine at what points additional measurements should be taken and to pick out spurious readings while they are still in the laboratory. The celluloid can readily be wiped off and re-used.

The laboratory work frequently precedes the classroom discussion of the topic. Indeed, the post-laboratory lesson is one of the most fruitful lessons of the week. Here the significance of the techniques, the limitations of the measurements, and the underlying concepts are thoroughly discussed.

The experiments are open-ended in that they invite the student to investigate the problems further. Usually the first half of the experiment is all that is absolutely necessary in order to develop the fundamental concept. It is imperative that the students perform the experiments themselves; this is not a teacher demonstration course.

(c) Films

This may well be the first time that the students have studied a course in which films perform such a significant function. As the course progresses the films play an increasingly important role in the presentation of the experimental data on which the concepts are based. It is suggested that preference be given for those films which develop ideas where it is necessary to use equipment not available in the secondary school laboratory.

Students must be suitably prepared for a film in order to appreciate the significance of the presentation. The teacher may wish to stop a film at one or two points to amplify or emphasize a point covered rather quickly in the film. Where possible it would be desirable to show the film a second time outside of the classroom period after the material has been elaborated upon by discussion.

The film loops on ripple tank phenomena may be very useful as a means of reviewing the observations of the students' experiments, particularly in schools where it is not possible to leave ripple tanks assembled in the laboratory for an extended period of time.

The advantage of having films closely coordinated with the curriculum is obviously partially nullified if the film is not available when required. Undoubtedly this situation will arise during the introductory year of any new course. The teacher can help to avoid this unfortunate circumstance by placing his loan or rental order early in the year. It is understood that many school boards are purchasing one or more copies of the films selected by their science teachers.

In Part B of this *Curriculum Study Guide,* a number of films with particular application to *Curriculum S.17C* have been suggested. Probably many teachers will be selecting much the same films for any given unit, but some variation will occur. The listing serves as a guide only, it is not intended to be a complete compendium of useful films.

(d) Objective Tests

The objective tests prepared for the P.S.S.C. Physics course provide a very valuable teaching aid. The tests provide excellent examples of the application of the principles to new situations. The post-test lesson is another instance in which exceedingly valuable discussions are held.

It is suggested that teachers obtain class sets of these tests and use at least one objective test after each unit. Because of the deletions that *Curriculum S.17C* makes from the textbook it will be found that some of the questions in the test must be omitted. It is suggested that these tests be valued primarily as a teaching device rather than a testing device.

(e) Science Study Series Books

Approximately forty titles are now available in this valuable but inexpensive set of reference books. It is suggested that a set of these books should be available in both the library and the laboratory. Additional copies of the titles most widely read should be made available. The books may be obtained with either hard or soft covers.

As many of these books have been written especially for students of P.S.S.C. Physics, they have a unique place on the reference shelf. It is hoped that the teacher will make frequent reference to material in these interesting books so that students are encouraged to read and expand their horizons in the field of science. The *Teacher's Resource Book and Guide* indicates the volumes which have particular application to each unit of the course.

It may be possible to use some of the books of this series as supplementary reading books for English classes in different grade levels.

(f) Teacher's Resource Book and Guide

Although mentioned last, this set of five loose-leaf volumes is a most useful aid to the teacher. The function which each unit performs in the development

of the entire course is carefully explained in the appropriate Resource Book. The contribution of each chapter to that function is then explained. It is invaluable as a guide to fitting together the textual material, the laboratory work, the films, the Science Study Series books and the problems so as to obtain full advantage of each. Complete problem solutions and helpful hints on experimental difficulties are of very practical assistance. It is essential that the teacher have access to this set of books.

As was mentioned earlier, problems must be selected with care so that the essentials are well established without overloading the students with many long hours of homework. The Resource Books classify each problem as to its relative difficulty and indicate by means of asterisks those problems which are particularly recommended for study. It is suggested that teachers regard the problems marked with an asterisk as a guide in the selection of appropriate problems.

The teaching schedule outlined in the Resource Books will be found to agree very closely with the time allotment suggested in *Curriculum S.17C*. The following unit schedule is considered to be valid.

Unit I completed by October 15, 1965.
Unit II completed by November 19, 1965
Unit III completed by February 22, 1966
Unit IV completed by May 13, 1966.

Teachers are urged to follow the above time limits closely. Experience has demonstrated that the most common cause of lack of adequate time for Unit IV has been the tendency to spend an unduly long period of time on Unit I. Many of the ideas newly introduced in Units I and II appear again in Units III and IV where they are developed more fully. It is intended that a given concept presented briefly in the early part of the course will have time to develop slowly in the students' minds before it is examined in detail later.

PART B/UNIT PRESENTATION

1. Unit I – The Universe

(a) Content

Unit I introduces the three fundamental concepts of physical science: time, space, and matter. By means of laboratory investigations the students learn how measurement extends our ability to understand these concepts. They become aware of the limitations of measuring devices and learn to evaluate the accuracy of the measurements. Although the topic of scaling is omitted from *Curriculum S.17C*, some teachers may wish to include a study of scaling where time and student interest combine to make this variation possible.

The study of kinematics is to some extent a review of material studied in Grade 11 Physics. However, the strong emphasis placed on graphical presentation of data and the interpretation of graphs will give the students a much deeper understanding of this topic than they had before. The use of vectors is also extended considerably beyond the students' previous experience.

The teacher will notice that in *Curriculum S.17C*, Unit I is concluded with the study of vectors. The study of matter as found in the remaining chapters of Part I of the P.S.S.C. textbook, *Physics*, is therefore additional material which could be used as an area of enrichment if desired.

The *Teacher's Resource Book and Guide* should be consulted carefully throughout the presentation of all Units.

(b) Laboratory Work

Curriculum S.17C specifies three experiments for Unit I. A fourth experiment, which is actually an exercise in graphical analysis, Experiment (1-4), is highly recommended. The experiment numbers quoted are taken from the *P.S.S.C. Physics Laboratory Guide.*

(i) Experiment (I-I)

This experiment emphasizes the fact that measuring devices are used to extend the human senses. Some students will have considerable difficulty in mastering the technique of using the stroboscope, hence, opportunities should be provided if possible for students to practise this technique after classes. Teachers may find it helpful to introduce the stroboscopic effect by means of a stroboscopic light.

The stroboscope will be used again when studying ripple tank phenomena.

(ii) Experiment (I-8)

The students will gain an insight into the use of assumptions in making calculations and the significance of approximations in obtaining a measurement to the nearest power of ten.

The students will experience the thrill of determining the approximate dimensions of molecules themselves.

(iii) Experiment (I-4) An exercise in graphical interpretation.

This exercise introduces the student to the powerful technique of graphing experimental data and analysing graphs in order to determine the mathematical relationship between the quantities concerned.

(iv) Experiment (I-5)

Although the experiment itself can be performed very quickly it must be realized that the analysis of the data obtained is very time-consuming. The inter-relationship of the distance-time, speed-time, and acceleration-time graphs must be carefully developed for thorough understanding. The second part of this experiment can be performed quickly using a hammer or some other object as the falling body.

In addition to the required experiments as outlined above, teachers may also wish to have their students use the parallax viewer to measure large distances and then modify this instrument so that it can be used as an optical micrometer for measuring very small distances. All experiments are to be regarded as open-ended in that they invite students to develop their own experiments so that they can enjoy the thrill of venturing into the unprescribed, unknown vistas of

science and learn to assess the value of their work most critically.

(c) Films

It is suggested that the following P.S.S.C. Physics film will be of particular value in the presentation of Unit 1:

0107 Straight Line Kinematics

2. Unit II – Optics and Waves

(a) Content

In this unit both the particle and wave theories of light are examined for their ability to explain the observed behaviour of light. As this behaviour has been studied in Grade 10, with further amplification in Grade 11, *Circular S-8 (1965-66)* indicates that topics one, two, and three of this unit will be omitted for the current year. It is suggested, however, that the teacher may find it helpful to review this behaviour quickly by means of a series of demonstrations.

The ability of the particle theory to explain many aspects of optics, but its inability to provide a complete explanation for light phenomena leads the student to a thorough study of wave behaviour by means of coil springs and ripple tank studies.

(b) Laboratory Work

(i) Experiment (II-7)

This experiment merits careful examination and repeated trial so that the students are able to see clearly the various phenomena involved. A coil spring suspended down the length of the laboratory by a series of threads and rings to an overhead wire provides a useful demonstration apparatus.

It is suggested that school corridors and foyers might be used if it is possible and practicable.

(ii) Experiments (II-8) to (II-12) inclusive.

The series of ripple tank experiments play an important role in the development of the wave theory of light. The teacher is however faced with the practical problems of space and time. In schools where a perimeter style physics laboratory is found or where ample storage room facilities are available it would probably be possible to leave the assembled ripple tanks undisturbed for several days. Where such facilities are not available every effort should be made to enable ripple tanks to be used by students for these experiments. Teachers have reported that six ripple tanks, three on each outside row of benches, have been left assembled and sitting on the desks without difficulty for an entire week, even though three different science teachers were using the laboratory. The problems involved can generally be solved in a manner appropriate to the local conditions.

Teachers in city schools will probably find it advisable to drain their ripple tanks daily using a siphon. The tanks should be wiped with paper towels after draining.

Experiment (II-13) is probably most effectively studied when performed as a demonstration.

(iii) Experiment (II-14) and (II-15)

The students are able once more to measure very small distances with reasonable accuracy. A second light source with a fine, long, wire filament can be used very effectively as a pointer at the meter stick to locate the position of the nodes.

The single and double slits should be prepared two or three days before this experiment is performed.

(c) Films

It is suggested that the following P.S.S.C. Physics films will be of particular value in presenting Unit II:

0201 Introduction to Optics
0202 Pressure of Light
0203 Speed of Light

The ripple tank series of film loops are undoubtedly useful.

3. Unit Mechanics

(a) Content

Throughout the study of dynamics there are references to the concepts developed in Unit I in the study of kinematics. The development of the wave and particle theory in Unit II not only presents an essential portion of the course, but, placed as it is between the study of kinematics and dynamics, also forms a suitable break in what would otherwise become a long, rather arduous study.

The unit opens with a development of Newton's Law and consideration of gravitational force. The two conservation laws of mechanics, the law of conservation of momentum and the law of conservation of energy are developed, followed by a discussion of the three forms of energy: kinetic, potential, and thermal.

It is to be noted that the study of simple harmonic motion has been omitted.

(d) Laboratory Work

(i) Experiment (III-2)

The techniques of this experiment are used in the next experiment also and hence warrant careful practice. Care should be taken to achieve as level a surface as is possible.

(ii) Experiment (III-3)

The student should perform both parts of this experiment. It is advisable to test the elastic bands for uniformity before selecting the bands to be used for part one.

(iii) Experiment (III-6)

The qualitative aspects of this experiment are readily obtained; however, meaningful quantitative measurements require considerable care. The teacher may find it advisable to have some students perform the experiment in the corridor if this is practical in his school, as a considerable area is required for each experimental station.

(iv) Experiment (III-8)

Although the measurements required for this experiment are easily made, they are noticeably affected by the extent to which the table surface has been levelled and by the smoothness of the surface.

(v) Experiment (III-9)

The velocities of the cart immediately before and after impact can be readily determined by extrapolation of the velocity-time graphs obtained from the tapes.

The students will find it advisable to support the brick so that it is only slightly above the cart before the brick is dropped.

(vi) Experiment (III-12)

Teachers are advised to have any new springs used for this experiment stretched with different masses the day before the experiment is performed.

The calculations involved in this experiment require considerable time.

It should be noted that experiments (III-4), (III-10), and (III-13) would be of interest and benefit as additional work for the interested student.

(c) Films

It is suggested that the following P.S.S.C. Physics films will be of particular value in presenting Unit III:

0301 Forces
0302 Frames of Reference
0309 Universal Gravitation
0318 Elastic Collisions and Stored Energy
0312 Mechanical Energy and Thermal Energy

4. Unit IV – Electricity and Atomic Structure

(a) Content

The electrical interaction between elementary charged particles is reviewed in considerable detail. Although the electro-magnetic spectrum is discussed briefly, the development of electro-magnetic theory has been excluded from *Curriculum S.17C*. It should be noted, therefore, that the second half of Chapter 29 as well as Chapters 30 and 31 of the P.S.S.C. Physics textbook are entirely omitted except for section twelve of Chapter 32, which is specified in Topic 4 of Unit IV.

It is in the final two topics entitled, 'Photons and Matter Waves' and 'The Structure of Atoms', that the various strands from which this course is woven are fitted together to form the exciting climax to the year's study. Many pupils and teachers alike have found that this course has been one of the most stimulating and satisfying courses in science that they have had the pleasure to study. The concluding topics form an invaluable conclusion to this experience.

(b) Laboratory Work

(i) Experiment (IV-3)

The inverse square relationship between electrical field strength and distance can be arrived at graphically from this experiment. Teachers are advised to have their students make several measurements at the larger distances of separation of the charged spheres. A laboratory model Van der Graaf generator can be used to supply a strong electrostatic charge on the spheres.

Considerable difficulty is frequently encountered with this experiment.

(ii) Experiment (IV-4)

This experiment, in which the vector addition of electrical forces is illustrated, can be performed very quickly so that sample calculations could be completed in the same period. High electrostatic charges are again of assistance.

(iii) Experiment (IV-6)

This is an interesting experiment which is related to the work of both Grade 11 Physics and Grade 12 Chemistry.

Note: The introductory experiments (IV-1)

and (IV-2) are simple but valuable in that the student becomes aware that similar arguments can be used to explain the observed phenomena whether a given electrostatic charge is called positive or negative.

(c) Films

It is suggested that the following P.S.S.C. Physics films will be of particular value in the presentation of Unit IV:

0403 Coulomb Law
0404 Milliken Experiment
0405 Coulomb's Force Constant
0409 Elementary Charges and Transfer of Kinetic Energy
0415 Electromagnetic Waves
0416 The Rutherford Atom
0418 Photons
0419 Interference of Photons
0421 The Frank-Hertz Experiment
0423 Matter Waves

Material	Source
a) Textbook materials The P.S.S.C. textbook, *Physics* *Teacher's Resource Book and Guide (5 volumes)*	Canadian Publisher Copp Clark Publishing Co. Ltd., 517 Wellington Street West, Toronto, Ontario
b) Related Reading Materials *Science Study Series*	Doubleday Canada Limited, 105 Bond Street Toronto, Ontario
c) Objective Tests Three sets of tests are available; *Series O, Series S,* (a scrambled version of Series O) and *Series N.*	Co-operative Test Division, Educational Testing Service, Princeton, New Jersey. U.S.A.
d) Films (i) Films on Loan A limited number of copies of each of the P.S.S.C. Physics films listed below are available for loan purposes: 0107 Straight Line Kinematics 0201 Introduction to Optics 0203 Speed of Light 0301 Forces 0307 Frames of Reference 0309 Universal Gravitation 0403 Coulomb Law 0404 Milliken Experiment 0416 The Rutherford Atom 0419 Interference of Photons	Audio-Visual Section, Department of Education, 559 Jarvis Street, Toronto, Ontario.
(ii) Films for Rent The P.S.S.C. Physics films may be rented or a purchase-rental arrangement may be obtained.	Modern Learning Aids, 1875 Leslie Street, Unit No. 13, Don Mills, Ontario
(iii) Films for Purchase The P.S.S.C. Physics films may be purchased.	Modern Learning Aids, 1875 Leslie Street, Unit No. 13, Don Mills, Ontario.
(iv) Film Loops The film loops prepared by Educational Services Inc. are available as indicated.	a) Canadian Laboratory Supplies Ltd. 80 Jutland Road, Toronto 18, Ontario b) Modern Learning Aids, 1875 Leslie Street Unit No. 13, Don Mills, Ontario.

e) Laboratory Apparatus

Complete kits of apparatus for the P.S.S.C. Physics experiments can be obtained from the sources indicated.

It should be noted that certain individual items of apparatus suitable for this course can be obtained from various scientific supply firms as indicated in their catalogues.

a) Canadian Laboratory Supplies Ltd.,
80 Jutland Road,
Toronto 18, Ontario.

b) Stark Electronic Instruments Ltd.,
540 Finley Avenue,
Ajax, Ontario.

c) Welch Scientific Company of Canada Ltd.,
16 Rivalda Road,
Weston, Ontario